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ORIGINAL ARTICLE

Living within the safe operating space: a vision for a resource efficient Europe

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Abstract A desirable future critically depends on our ability to ensure the supply of key resources while simultaneously respecting planetary boundaries. This paper looks at the potential implications of living within the "safe operating space" for people, business and the economy. It develops a positive vision of the future based on three pillars: a safe and fair use of global resources, a sustainable society, and a transformed economy. We review and build on recent sustainability visions to develop a holistic reflection on what life in 2050 could look like, and explore the key changes in the economy needed to get there. In particular we show that resource efficiency requires a systemic shift in values, innovation, governance and management regimes. We present a bold vision for Europe underlined by indicators and targets, explore transition challenges to getting there and conclude with a list of key policies needed for overcoming challenges and reaching the vision.

Keywords Resource efficiency · Visions · Sustainable development pathways · Green and inclusive economy · Policies · Eco-innovation

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Introduction

Achieving sustainability targets has become increasingly complex. Societal challenges, such as building inclusive, innovative and reflective societies within the resource constraints of a 2 °C planet, are interconnected and cut across multiple sectors, levels of policy, and areas of society. The time when environmental policy could react to solve single-issue problems, like cleaning-up water bodies and closing the ozone hole, is over. The challenges today require pro-active policies that address production and consumption across all aspects of the economy in a precautionary manner. Not only pockets of greening—like lead markets in environmental technologies or isolated social movements promoting a change in lifestyles – but a transition to a resource efficient, circular, and equal-opportunity economy is needed. There is a need for systemic change to overcome old paradigms (like the blind pursuit of GDP growth), which have proven inappropriate to tackle global challenges.

In her article on envisioning a sustainable world, Donella Meadows argues that "Vision is the most vital step in the policy process. If we don't know where we want to go, it makes little difference that we make great progress. Yet vision is not only missing almost entirely from policy discussions; it is missing from our whole culture" [1]. Since then, a number of visions have emerged, developed both in policy documents [2, 3, 62] and by powerful coalitions of stakeholders and experts [5, 6]. Yet little, or painstakingly slow, progress has been made on turning visions into concrete policy actions. An informed, societal discussion on visions as well as societal engagement in the visioning processes remains almost entirely absent.

One could argue that the scope of the challenge was already officially and internationally recognized in 1992. Agenda 21 states:

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> "Special attention should be paid to the demand for natural resources generated by unsustainable consumption and to the efficient use of those resources consistent with the goal of minimizing depletion and reducing pollution. Although consumption patterns are very high in certain parts of the world, the basic consumer needs of a large section of humanity are not being met. This results in excessive demands and unsustainable lifestyles among the richer segments, which place immense stress on the environment." [61]

With the exception of some positive and remarkable achievements of sustainability transitions, mainly on the local and regional level, special attention to natural resources and unsustainable lifestyles has yet to be given in a coordinated, comprehensive and structured way. Humanity's ecological footprint has significantly increased since 1992. This paper argues that there are at least two main reasons for this failure.

First, there seems to be no basic disagreement about the core elements of the challenge or the vision in major documents produced over time and by different types of stakeholders. All support the eradication of extreme poverty and hunger across the globe, the maintenance of key earth support systems needed to sustain human life and that of future generations on a stable planet, and the basic human rights of freedom, justice and peace. The disagreement is on how to get there. The challenge is pinpointing the key elements to a smooth transition to societies that work within ecological limits. This paper presents some of the elements we see as crucial along the transition.

Second, visions picturing a world characterized by sustainable resource production and consumption have not been adequately turned into targets for sustainable resource use. Without clear targets for what a sustainable level of resource consumption entails, there is no reference for knowing whether consumption levels for specific resources are pushing the limits of the planet beyond what may be considered sustainable. Scientific understanding on the planetary boundaries has improved significantly in recent years, notably through the flagship publications of Rockström and colleagues [7]. Those publications have developed the concept of a "safe operating space", which will allow humanity to continue to develop and thrive within the biophysical boundaries for keeping the Earth within the Holocene. The challenge is linking the safe operating space to quantifiable, concrete and transparent targets for the consumption of natural resources. Some countries (including in particular Sweden and Switzerland) have already taken up this challenge [8, 9]. This paper reviews and presents key targets for sustainable resource use in the context of our vision for a resource efficient Europe.

The purpose of this paper is to develop a holistic vision to consider what living within the safe operating space could mean and to explore the key changes to getting there. We review past visions and highlight strong and weak elements within the visions themselves. In comparison to other recent visions, our vision looks more closely at how human needs for all can be met within the safe space of resource use to balance environmental objectives with human well-being. We present some key transition challenges for people, business and policy and list key policies to overcome these challenges. Finally, we conclude with a discussion of research needs, in particular related to how visions may support policy processes in the EU.

Review of key sustainability visions

A number of visions, pathways and scenarios describing possibilities for what a sustainable future world looks like have been developed recently. Notably, the European Commission published the "Roadmap to a resource efficient Europe" in 2011 with a vision for 2050 of a competitive and inclusive economy that operates within the planetary boundaries [3]. Some of the most popular recent vision documents from the literature include "Vision 2050 – the new agenda for business" from the World Business Council for Sustainable Development [6]; "World in Transition: A social contract for sustainability" by the German Advisory Council on Global Change (WBGU) [10] and the "The Great Transition: The Promise and Lure of the Times Ahead" by the Tellus Institute [11]. This set of visions is a good example of the spectrum of papers applying a visioning approach.

In its 2050 Vision the WBCSD sets its overall objective as the decoupling of economic growth from ecosystem destruction and material consumption, and re-coupling with sustainable economic development and societal well-being. The WBCSD's *Vision 2050* promotes the viewpoint that radical changes in policy and lifestyle would, over the next 40 years, make corporate environmental efficiency a competitive advantage across all industries and regions of the world. The vision highlights the sustainability-related global business opportunities in natural resources, health and education and adopts a rather production-oriented vision, with e.g. the key policy intervention focused on getting the price right (carbon price, payment for eco-system services, „true value", etc.). The sustainability challenge presented by WBCSD seems to focus on finding answers to the question of how to best maximize utilities by minimizing the costs. The consumption perspective is hardly addressed.

In contrast the WBGU flagship report presents a holistic approach describing the transformation into a low-carbon society until 2050 in the tradition of Polanyi or the New Economics Foundation [12, 13]. This transformation reaches far beyond technological reforms, and will be the result of the "concurrence of multiple changes" [14] among key transformation fields: energy (including the transport sector),

urbanisation and land use (agriculture and forestry, including deforestation). The key driver for a societal change towards a low-carbon society is a cultural change by a new "global social contract" carried out and performed by a proactive state and change agents – or pioneers of sustainability – by means of a culture of participation and obligation towards future generations. Climate protection is the highest common goal of this society.

"The Great Transition Today" [11] presents a vision using a narration of the world at the end of the 21st century. The age of nations is past and three types of regions implemented the requirements of the new "World Constitution" on a local level, ensuring quality of life, human solidarity and ecological sensibility. Societies are generally disarmed and constituted by global citizens that share responsibility on a global level but are regionally autonomous (constrained pluralism – "unity in diversity"). By drafting such a powerful and colourful vision, Raskin et al. neglect to consider any type of resistance against such a progressive global society, either from economic and political elites, social movements, indigenous people or academic discourse.

In addition to these forward-looking visions, a number of additional studies apply a backcasting approach. These studies "backcast" from worst-case scenarios to anticipate policy challenges for overcoming prospective dilemmas. Examples of such studies include "Our common journey: A transition towards sustainability" [15] and "Getting into the Right Lane for 2050" [16]. For example, the latter uses model-based analyses to discuss issues such as producing food for a global population of nine billion people while minimising biodiversity loss; mitigating climate change processes while enhancing energy security for Europe; as well as establishing practical solutions for a European-wide transport system that is low carbon.

In confirmation of Donella H. Meadow's critique [1] that contemporary visions primarily describe implementations and pathways while neglecting or minimizing the proper story or narrative, many present-day visions seem to lack a clear distinction between the narratives (vision) told and the pathways (implementations) described. The review has shown that all visions argue for changes in the current socio-political system to overcome certain socio-political barriers to sustainability (changes of business strategies, governmental structures, individual and collective lifestyles and levels of cooperation). Generally, these changes will be performed by particular key actors in the transition process, which often ends in a strategic selection of actors, so called frontrunners or pioneers, according to particular self-interests rather than in an ontological choice according to the relevance of the expected future needs (as in the case of WBCSD addressing businesses and WBGU and Raskin et al. highlighting change agents and global citizens as key actors).

Available visions show that the specific problem of socio-ecological transformation requires special efforts and may not be solvable by conventional means. More theoretical considerations and inter- as well as transdisciplinary approaches could help to discover common blind spots and to transcend the established tracks of problem-oriented public policy. This includes for example a critical discussion of a strong "male-white-westerner" bias of the visions, the integration of indigenous knowledge or the consideration of real gender equality and emancipation. Ongoing debates in Latin America [17] show that established western discourses could be inspired by the progressive force of real visions (e.g. "buen vivir" from Latin America).

Vision and pathways to a resource-efficient Europe

Our vision of a resource-efficient Europe in 2050 is characterized by three "pillars": (1) A safe and fair use of global resources, (2) a sustainable society, and (3) a transformed economy. Figure 1 describes the key characteristics of these pillars in detail and depicts how the first pillar frames the second and third pillars.

The vision was developed through a literature review of other visions, as well as through a vision workshop (July 2013) and stakeholder workshop (December 2013) within the framework of the EU-supported research project "Policy Options for a Resource Efficient Economy" (POLFREE). The aim of the visioning exercise was to identify particularly relevant areas for European policy interventions toward resource efficiency. Such interventions are not intended to prescribe how the transition should happen, but rather to provide the framework conditions that would allow the transition process to flourish (perhaps also in unexpected ways).

Sustainable resource use

The vision of sustainable resource use is underpinned by credible, scientifically-derived and measurable targets for resource consumption in the four categories: materials, land, water and carbon. These categories were chosen to be consistent with the dashboard approach of the European Commission [3] and the four footprint approach suggested in the literature [18–20]. Such targets set the end-point against which the success of different policy interventions can be measured and should be based on the concept of using "a fair share" [21] of the safe operating space for the EU. In other words, these targets should lead to both a level of consumption that is within the planetary boundaries and in which activities do not cause the transgression of other planetary boundaries. Thus, targets should either be directly derived from the safe operating space concept, or be tested against the safe operating space framework (e.g. to avoid problem shifting between environmental pressures). At the current time, work to

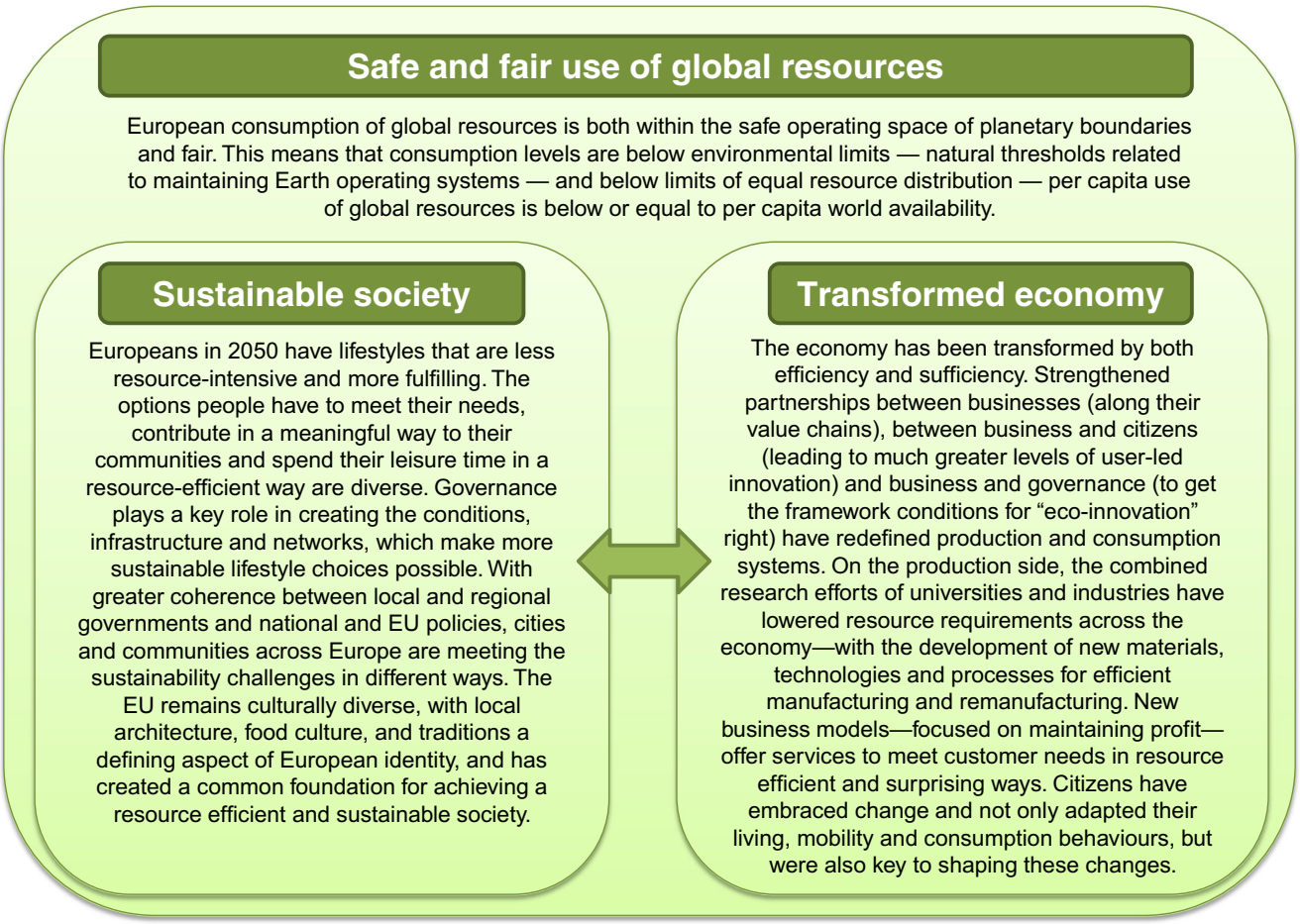

Fig. 1 Vision, pillars and characteristics of a resource efficient Europe in 2050

develop such targets in each resource category is ongoing, with some areas more advanced than others.

Table 1 presents the current stand of research on the resource use targets underlining the vision. Per capita targets are used in keeping with common practice as a reference for a fair distribution of global limits [22]. These per capita targets do not imply a distribution of resources at the individual level, but do provide a comparison of average resource consumption levels at the country (or EU) level. In this way countries may account for their resource consumption to understand whether they are contributing to an overuse of global resources as a nation. As such, these targets could be considered flagship targets, or reference values, for resource consumption levels indicating global fairness. Accompanying policies at a country (or EU) level would be needed to deal with questions of social inequality and unequal vulnerability.

The use of global per capita targets means that targets are also contingent on current levels and expected growth of world population. This highlights the urgent need to address population growth as well as the need to set easy-to-communicate, long-term targets establishing the direction for change, with short to mid-term targets depicting the concrete scope of the challenge.

While the vision focuses on the kinds of changes needed to reduce consumption levels toward more sustainable levels, it is also based on the premise that natural ecosystems within the territory of the EU are managed according to environmental objectives for biodiversity, nature conservation and environmental quality. This implies reaching existing, as well as anticipated regulations and targets for natural resource management, in particular in extractive industries (e.g. mining, forestry, etc.) but also across the economy and society (e.g. halting land take, reducing CO_2 emissions, etc.).

Sustainable society

Recognizing that there is only one planet, Europe aims for convergence in resource use on a planetary scale, while celebrating the diversity of societies and cultures that flourish on the Earth. In 2050 the world population has stabilized at around nine (at least 8) billion people [4]. In Europe more than 50 % of the population is over 60 years of age [4]. New

Table 1 Resource consumption targets

	Materials	Land	Carbon	Water
Target	10 t $TMC_{abiotic}$ / person[a]	0.20 ha cropland / person[b]	1.05 t CO_2 / person[c]	Not quantified
Implications for EU citizens by 2050	ca. 70 % reduction compared to 2008	ca 45 % reduction compared to 2007[d]	ca. 90 % reduction compared to 2010	(ca. 30–50 % reduction compared to 2004)[e]
Source	Bringezu 2011 [54]	UNEP 2014b [55], Bringezu et al. 2012 [56]	Roelich et al. 2011 [57]; Lenzen et al. 2012[f] [58]	Roelich et al. 2011 [57]
Rationale	Return to a global level of mineral extraction equivalent to the year 2000 (without considering erosion)	Halt the loss of biodiversity and keep land use change (LUC) within the safe operating space	Keep global warming within 2 degrees Celsius (67 % probability)	Scenarios based on potential efficiency improvements and demand-side reductions under four "One Planet" scenarios
Calculation	Global total mineral extraction in the year 2000 divided by expected world population in 2050	Max cropland area of 1.6 Mha divided by expected world population in 2030	Global cumulative cap of 750 $GtCO_2$(WBGU 2009); budget of 9.6 $GtCO_2$ in 2050 divided by expected world population in 2050	–
Research needs	Link global resource extraction to social acceptance of impacts (e.g. as regardscriticality and pollution)	Develop targets for forests and pastures; better understand potentials for winning back abandoned land	Expand the target beyond the CO_2 portion of the carbon footprint	Quantify a global target or explore possibility of regional targets that may be linked to global safe operating space

[a] Indicators differ significantly for quantifying the material footprint depending on how comprehensively they account for consumption. TMC (Total Material Consumption) takes both indirect flows (only at national level) and used as well as unused extraction into account. The European Resource Efficiency Platform suggests using a target based on Raw Material Consumption (RMC) which equals DMC at the global level. This indicator does not include unused extraction. Using the same logic as in Table 1 a target of 5 t $RMC_{abiotic}$ / person has been calculated [59]. Bio Intelligence Services 2012 [18] suggests a target for Domestic Material Consumption (DMC), which equals RMC at the global level but would exclude indirect used extraction at the national level and thus only give a partial picture of consumption effects, of 5 tonnes DMC / person. This is based on reducing fossil fuels by 95 % to meet GHG emissions targets, reducing minerals by 85 % to stabilize built-up stock and halt land take, stabilizing biomass consumption and focusing on the recycling potential of metal ores

[b] target refers to the base year of 2030; continued population growth and expansion of built-up land would further reduce the target, whereas land restoration (e.g. of abandoned land) could mitigate some of these effects. The timeframe of 2050 is too far to anticipate such trends; instead 0.2 ha is proposed as a clear, easy-to-communicate and directionally safe target

[c] Study presents as a carbon footprint "benchmark" and not as a target per se

[d] This range depicts the potential footprint savings in society for different transition pathways in the EU, but does not reflect a sustainability benchmark based on what may be considered a sustainable level of resource use (in other words a boundary „defined"by the natural conditions)

[e] Note that this reflects the scale of the challenge until 2050 to be consistent with the ranges presented for the other targets. It thus assumes continued population growth until 2050 and a reduced per capita availability of cropland (e.g. around 0.17 ha) and is for indicative purposes only (see note iv above)

[f] Based on data provided in the Eora MRIO Database and calculated by the authors

forms of health and care systems, pension systems, as well as adapted housing and mobility opportunities have been developed. Human rights are upheld and people have equal access to chances and capabilities. The divide between the rich and poor has been reduced (e.g. through limited income gaps) and across the globe migration out of poverty or because of extreme events has also been reduced due to the internationally fairer distribution of resource access, income and other opportunities. The migration that still exists is valued, because it enriches the diversity of national societies.

Through new initiatives in education and awareness-raising, people understand that they are connected to each other and to nature and that humans are dependent on a healthy natural system, which has a value on its own. They now know that maintaining this requires new lifestyles, characterized by voluntary simplicity and contentment. Nonetheless, quality of life is still high. People are increasingly satisfied by services and experiences rather than by simply purchasing goods [23]. They are using instead of owning, sharing instead of possessing and appreciating longevity of high-quality products. New sharing-systems and forms of collaborative consumption are established by users directly through peer-to-peer networks or by businesses. The growth of such schemes

is facilitated by the emergence of new technologies that connect suppliers and users. Changing practices (such as no longer wasting food or washing clothes at high temperatures) or upgrading, reusing, repairing or recycling products are encouraged through information provision, awareness-raising campaigns, and economic incentives (e.g. in the tax structure).

Lifestyle changes have resulted in an absolute decline in energy and resource use. They were encouraged through information and education campaigns appealing to people's intrinsic motivation and policies which enabled the true costs of resource consumption to be reflected in the price of goods and services (e.g. removal of environmentally harmful subsidies across all sectors of the economy). This has transformed the way people work, live, eat, move and learn.

For example, more and more people express the wish to "downshift" their working hours per week [24], which has led to gradual changes in the patterns of work, the weekly working hours, and the life/work balance [25]. The combination of demographic changes, reduced labour supply and diminished growth of labour productivity, has resulted in a trend of slowed-down GDP growth. Labour productivity has still grown faster than GDP, thus social partners and governments have installed further incentives to reduce working hours so that full employment has been achieved [25].

There is a large movement of collective multi-stakeholder and participatory approaches to urban planning and the design of transport and other infrastructures that support compact, complex and efficient cities with strong social cohesion to promote sustainability and well-being. Reorganisation of the structure of urban development and especially of public space in the core of cities gives more space to pedestrians, bicycles and public transport on the one hand and shared public space, e.g. for urban farming, on the other [26].

Reconstruction of existing buildings also aims at increasing the average density of resident population and was accompanied by a trend to reduce the average amount of floor space (housing) per person compared to 2014, while common space areas increased. Socially innovative and resource-, water- and energy-efficient modes of housing, such as co-housing communities, urban co-ops and communes reflect greater environmental awareness and societal value for community living [27].

The preferred way to move in cities is biking and walking. Local mobility is emphasized and less road space is devoted for private vehicles. Car-sharing systems dominate the use of vehicles when public transportation is not used, while shared offices enable people to work closer to their homes. The huge share of work-related mobility and commuting is decreased by the expansion of teleworking and by reorganization of urban space and the labour market.

As a result of innovative urban planning concepts, new forms of living and different mobility patterns, urban sprawl has declined and was replaced by very productive urban farming initiatives [28]. By developing awareness and collective supporting networks, people better understand the impacts of food choices on the surrounding environment and their health and choose to adopt diets much lower in animal products [29, 30]. An increasing number of consumers are seeking information on the conditions under which the products they purchase are produced and transported. Demand for local, organic, seasonal and self-grown foods as well as Fair Trade markets are growing, reinforced by programmes in schools aimed at reconnecting children to the origins of their foods as well as 'sustainable food' procurement by public authorities [31]. At the same time the amount of food waste has decreased substantially in households and retail).

In 2050 Europe has an innovative, open knowledge system [32] that is supported by formal and informal education and capacity building. The general ambition is to protect, promote and whenever possible integrate the multiple forms of knowledge (not only scientific) and the diversity of languages, concepts and models in ways that support transitions to sustainability. Europeans understand that experimenting and learning is essential for adapting to complex, changing conditions and requires learning to learn and learning to co-produce and implement new and prior knowledge in an iterative loop of learning, doing, and reflection.

Transformed economy

Mainstream economics have been transformed by 2050. The new European growth strategy focuses on achieving growth in well-being. The indicator GDP is accompanied by a dashboard of indicators to measure success in social development and progress in sustainability, and GDP itself has been adjusted to reflect "positive growth". Clear, coherent and binding targets for environmental, social and economic developments set a framework to guide policy and administrative decisions on local, regional, national and EU levels.

A shift in culture, thinking, values and education (see above) has led to new patterns of consumption and production, which have opened up new business opportunities. Business models and innovation strategies align business with environmental and social objectives. Measures of success are geared towards delivering the highest overall (social, environmental and economic) value, rather than just financial return. A harmonized and transparent eco-labeling system and other smart regulatory tools allow citizens to make more informed and sustainable purchasing decisions.

Overall, the manufacturing industry has been transformed to respect the limits of non-renewable and renewable

resources. Products are designed for longevity, durability, remanufacturing and recycling. Effective systems of material stewardship and global extended producer responsibility have led to closed-loop design and the development of a circular economy [33] in the EU. This has dramatically reduced the EU's demand for primary resources and lowered imports, in particular metals.

The substitution of services for products has emerged as an increasingly popular business model and dematerialization and service-based consumption have become a major trend in European society [34, 35]. Such innovative business models are not built on the premise of selling more (and more) physical goods, but on the idea of satisfying consumer needs through access to and use of products, which are maintained over the long term by the service provider. Traditional sharing, bartering, lending, trading, renting, gifting and swapping have been redefined through persuasive technologies and peer communities and has transformed consumerism and the way people live [36].

The willingness to cooperate along with technological breakthroughs has been supported by eco-innovation policies for a green economy [37]. The new economy is not only characterized by an integrated, high quality European recycling infrastructure, but also by more "informal loops" in re-use. It cuts across all sectors of the European economy, including the recycling and up-cycling of construction minerals (e.g. urban mining). At the same time, industrial symbiosis has become a normal business practice and most European companies have internalized this approach to resource management [38, 39]. European companies in 2050 apply methods like material flows analysis, Life-cycle assessment and material input per service unit (MIPS) [40] as common practice to compare and identify new business strategies, in particular as regards end-of-life product options.

Innovative business models have in particular required engaging in new strategic innovation collaborations with other businesses, research, customers as well as with public administration. These new collaborations have become an important inspiration for radical systemic innovations. The new models triggered stronger links with customers to respond to people's needs and co-develop and design new services and products that connect to (changing) customer needs and values in a spirit of open source and open innovation [41].

Transition challenges

Transitions are long-term radical changes of social systems [42]. They are difficult to govern, especially with regard to global diffusion, but can be influenced and even managed. A dual strategy of incrementally improving existing systems under the prevailing 'rules of the game', while simultaneously developing radical system innovations that fundamentally transform those rules and prevailing patterns of production and consumption, captures such attempts. Research done in the Sustainability Transition Research Network (STRN) stresses the importance of three levels for such changes:

- Niches, quite often locally rooted, where new ideas can be tested and new products enter the markets
- Regime changes, where successful demonstrations have been turned into early markets that alter prevailing socio-technological regimes
- Landscape alterations with large-scale changes at the level of infrastructures, countries or cultures, where old technologies are replaced by new systems, often along with rule changes.

Analysing ongoing change processes worldwide, it seems that there is no shortage of new niches, usually characterized as 'best practices' or 'green technologies'.[1] Yet it is much more uncertain, to which extent existing regimes are being altered or landscape alterations take place. The patchwork of incremental changes may remain stuck in niches (such as lead markets) or be isolated in a few pioneering regions. Structural barriers embedded in the social and economic framework "lock-in" development pathways, making landscape alterations particularly challenging. Examples of such structural barriers include e.g. vested interests of asset owners that make them less favourable to radical innovations and long investment cycles in e.g. infrastructures (like roads and power stations) that favour established economic practices and actors [43]. Our vision is based on a combination of bottom-up and top-down changes that includes both step-wise incremental processes and structural changes in the way societies and economies operate and are governed. A key aspect seems to be going beyond the support of niches and regime changes to address landscape alterations by identifying and tackling structural barriers. We highlight five key challenges to managing the transition toward our vision.

Overcoming the fears and uncertainties change is generating

Although an increasing share of people feel that their lifestyles do not make them happy and recognize (1) that their life satisfaction is not growing with their accumulated wealth (beyond a certain point [44]), (2) that extreme poverty and hunger plague nearly 900 million people across the globe [45], and (3) that overconsumption is contributing to extreme and risky environmental degradation, they do not change their

[1] See e.g. http://www.ggbp.org

way of living. This is called cognitive dissonance or the belief-behaviour gap [46]. One reason for this gap might be that the effect of changes of habits, social practices, and consumption patterns on one's well-being are uncertain and this creates fear. Thus, to enable a transition, people should be supported to overcome this fear by, for example, being able to experiment with a new lifestyle (visiting eco-villages, being for a while a member of a time bank, being offered only vegetarian foods in the canteen, etc.), or getting to know role models that do live a new lifestyle and are positive about their experiences. Policy options include implementing appropriate institutions and framing conditions, from new forms of education, free courses in mindfulness or non-violent communication, appreciative dialogues, free vegan cooking or gardening courses to changing rules and norms that allow using the streets to walk and play instead of driving. By feeling the effects of doing things differently one can reduce his or her fears.

Overcoming vested interests in the status quo

Transitions might be blocked due to vested interests in the status quo by people who have power in the current system, be it politicians, business people or other decision makers. Waiting for a value change of those persons might take too long. Here pressure from civil society might lead to changed perceptions of those in power. Therefore new forms of direct democracy and public participation that has decisive power, as described in the vision, are needed.

Overcoming lock-ins related to infrastructure

Long investment cycles in infrastructures (e.g. road construction and maintenance or investments in power stations) hinder radical and rapid change. One strategy to cope with lock-in related to advancement of the circular economy, namely incineration of municipal waste, could be the development of an integrated European recycling infrastructure that would allow new recycling facilities and existing incineration plants to operate at economies of scale. While asset-specific investments characterize resource-intensive sectors such as mining, electricity production, construction, automotive production, etc. and take time to adapt, research also underlines cognitive and institutional dimensions and the ensuing need for new orientation.

Empowering eco-innovation and the development of eco-innovative goods and services

Supporting companies to overcome internal barriers to eco-innovation (in particular by providing eco-innovation financial support, promoting skills, and raising awareness) will enable business to – more quickly – meet the business opportunities of the vision from the bottom-up. Policies are needed for such 'enabling conditions', along with mechanisms to phase out environmentally intensive patterns.

Bringing actors together to create the kind of systemic change needed

It is important that bottom-up movements and top-down processes are interlinked, so that new institutions, production and life modes can be co-created by different actors. This requires the creation of spaces characterised by openness, appreciation and trust, where actors can meet on the same levels and openly discuss their ideas, solutions and also concerns. Those spaces can be created by so called intermediaries, such as regional managers, NGOs, or specially trained facilitators.

Governance

Overcoming structural barriers and managing transition challenges does not only require radical changes in government policy but also in the current systems of governance (the orientation of society and patterns of interaction over collective issues) [47]. Within a multi-level, polycentric governance system, cooperation rather than competition should guide the future approaches to dealing with resource-efficiency in Europe [48]. The deepening and broadening of stakeholder engagement processes in all levels of governance based on a new "social contract" [10] would help to recognize the joint responsibility of states, business, science, civil society and even individuals for tackling sustainability challenges. Participatory processes lead to increased trust and new forms of interaction between the different societal actors, who bring together creativity, resources, capacity, legitimacy and political will to achieve common goals [48]. This fosters societally relevant innovation and supports effective decision-making at all levels. It also empowers citizens and non-governmental organizations to create a strong bottom-up process that may drive the transition to a more sustainable and resource-efficient Europe.

The development and implementation of Sustainable Resource Management Programmes could provide a harmonized approach for governing the use of natural resources within the safe operating space. It could set the basis for establishing a long-term, holistic target-setting approach and instituting a monitoring and reporting system to ensure that progress towards targets is carried out at all levels. At the same time such programmes may provide the structure for pursing the aims of decoupling wealth and resource consumption (taking into account the resource nexus, i.e. the linkage between different natural resources), ensuring supply security (food, raw

materials, etc.) and nature conservation. Such efforts would make the EU a global leader for sustainability and position the EU to be a champion for democratically legitimated global governance, which is strong enough that planetary boundaries are respected.

Key policies

Given the high level of ambition of the vision outlined above, it is clear that although the economics of resource efficiency has made compelling arguments – e.g. about the relevance of material purchasing costs to manufacturing business [60] – the markets alone will not be sufficient to initiate the aspired transition towards a resource-efficient Europe. Neither the business tools of integrated environmental management nor classic environmental policy tools can deliver such systemic changes at the level of landscape alterations. Nevertheless, the key insight is that materials and other resources are economically relevant, both for business and for macro-economic perspectives. Seen from a policy perspective, this could offer advantages of alliances with traditional policy actors. Furthermore, a coherent and consistent policy mix for resource efficiency is necessary [49–51].

Within the main sectors responsible for resource use (housing, food and mobility) as well as the energy sector, a wide range of policies would support the achievement of the vision. For instance, in the energy sector, regulations requiring regular billing with clear consumption and cost information would provide consumers with incentives to increase energy efficiency. Achieving the vision would also be supported by policies to bring a significant portion of electricity grids under local government or community ownership by 2020. In the mobility sector, policies to support the use of public transportation through, for example, the introduction of multimodal tickets, congestion charging in urban areas and reduced taxes for shared vehicles would lead to reduced resource use in ways that support the vision. In the food sector, policies to support the widespread application of the principles of agro-ecology in agriculture, urban gardening in and around cities and dietary change would also support the achievement of the vision.

In addition to the policies that are directed at particular sectors, there are a number of key policies that are aimed at resource use in general and thus affect multiple sectors. Based on an intensive literature review and stakeholder consultations within the POLFREE project, the following list of key policies and policy actions have been identified:

- Minimization of food waste losses alongside the value chain / Shifting away from diets with excessive meat consumption
- Bridging the valley of death for eco-innovations / green financing
- Requiring low to zero-energy and material-efficient buildings
- Requiring fuel-efficient mobility
- Increasing efficiency in electricity production and distribution
- Establishing an industrial symbiosis network
- Implementing product service systems
- Introducing eco-design product standards for a circular economy
- Phasing out environmentally harmful subsidies
- Internalizing of environmental costs

Cross-sectoral impacts would also be associated with an educational reform across the EU in order to integrate systemic approaches to problem solving and to ensure basic education about all aspects of sustainability [19]. The latter is a basis for much of the transformation that takes place in the vision for a resource efficient Europe, which relies on massively raising awareness among citizens about the risks associated with continued and increasing high use of resources, as well as the opportunities for enhancing quality of life through a reduced use of resources. Basic education is an important part of this awareness-raising, as are campaigns to highlight the opportunities offered by, for example, co-housing, product-service schemes, and car sharing.

In order to achieve this ambitious and transformational vision by 2050, the policies need to kick-in sooner rather than later. This is also reflected in the EU Resource Efficiency Roadmap, which calls, for example, for both the removal of environmentally harmful subsidies and the introduction of a "green tax reform" by 2020. The latter policy change would pave the way for many other policy initiatives, since through reducing labour costs it would make many other elements of the vision more feasible (e.g. repair, reuse and recycling). Furthermore, having prices "tell the environmental truth" would send clear signals to citizens about the consequences of their actions.

A final aspect of underpinning the vision through policy is the need for an adaptive policy environment [52]. Achieving the vision for a resource-efficient Europe will require experimentation, learning-by-doing, and regular monitoring of progress towards the goals.

Discussion and research needs

The vision anticipates a societal transformation toward a green economy characterised by a combination of changes in values, business models, and governance. It is a bold vision for Europe grounded in ambition, and it is the basis for further elaboration and exploration toward finding the right policy mix for enabling a resource-efficient transition.

In times of unequally distributed power resources, of technological lock-ins and path dependencies the joint formulation

of visions and common goals helps actors to coordinate their actions [47]. From this point of view the vision is not an instrument to develop measurable goals, but a more strategic process to bundle expectations, to overcome short-term thinking and to define common interests in fundamental change. In this sense, visions provide an alternative selection environment compared to established socio-technical paradigms [53].

Research is needed to make the concepts, components, and elements of the vision meaningful and applicable at different levels of application. In the context of an overarching transition, selected focus areas may be identified and elaborated where (a) different more tailor-made visions might be developed, (b) elements of an overarching vision shall be maintained (e.g. sustainable Europe without problem shifting) and (c) a permanent interaction between real changes and such visions become institutionalized. Research is needed in particular on the role of citizens and how to overcome the belief-behaviour gap, to create spaces of trust where bottom-up and top-down can meet, and on what individuals really need to dare to try new lifestyles. In particular, greater understanding of the types of changes needed to power the transformation at the level of landscape alterations and the role of incremental versus radical changes could strengthen policy development to overcome barriers.

Targets help to set a clear orientation, provide guidance and prioritize actions toward achieving objectives. If properly enforced and supported by an appropriate policy-mix to ensure fair (global) market conditions and a level playing field, they can be a powerful approach to addressing environmental issues in alignment with other objectives. Long-term objectives provide actors in society, particularly governmental organizations and companies, certainty, stability and time to achieve the target in the most efficient manner. Research is needed to:

- expand on the headline targets with specific targets for sub-areas, such as a sustainable level of fish and timber consumption;
- strengthen the link between safe operating space and targets in a scientifically sound way, in particular for material resources;
- support the process of setting targets by analysing interlinkages and trade-offs between them and a variety of higher objectives;
- make national (or global) targets both meaningful and implementable at different levels of application, e.g. through "operational" targets which take the actual capacity to change a targeted economic model and socio-economic system into account, and which could be co-developed by stakeholders in the context of overarching targets [43].

Overall, staying within the safe operating space requires new forms of adaptive governance and a systems perspective that recognizes the dynamic links between the social, ecological and economic system and between the different levels of our society (macro, meso, micro). The vision provided in this article is a starting point to highlight the kinds of changes we think are needed to live well within the safe operating space. The POLFREE project will continue to work with this vision using a modelling exercise to test the feasibility of different possible pathways with results available in 2015.

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